



# ***EUROGRAM***

***EUROPEAN OFFICE OF AEROSPACE RESEARCH AND DEVELOPMENT***

## **CC HIGHLIGHTS**

AFOSR's Director, Dr. Joe Janni, and a delegation of AFOSR personnel just returned from a two-week trip to research sites in the United Kingdom, Israel and France. Dr Janni was accompanied by his deputy, Colonel Steve Reznick, his Director of Physics and Electronics, Dr Jack Agee, Director of the International Office, Dr Yolanda King, the EOARD Commander, Colonel O'Connor, and EOARD Chief of Policy and Strategy, Dr. Phillips. The UK visits are described elsewhere in this edition of the Eurogram.

Dr Janni met with the Israeli Ministry of Defense's Head of the Research & Technology Base Unit, Dr Meir Weinstein, and with the French Armament General Delegation (DGA) Head of the SREA, General Estournet. AFRL's interest in international cooperation was discussed with both countries as well as AFOSR's specific role in basic research and international cooperation. While in Israel, the AFOSR contingent visited an Arrow missile facility and toured many facilities at Technion, the Israel Institute of Technology, as well as Tel Aviv University and the Weizmann Institute of Science.

After the DGA meeting, the AFOSR contingent toured facilities at ONERA Palaiseau and the Ecole Polytechnique in the Paris region. The group then went on to Toulouse region, where similar briefings and tours took place at the Centre National d'Etudes Spatiales (French space agency), ONERA/Toulouse, and the Centre National De La Recherche Scientifique.

Watch for further developments of this visit as AFOSR program managers follow up on the many interesting opportunities for grants, contracts, Windows on Science, and government-to-government cooperative efforts. In particular, Drs. Fredell, Raffoul, and Sellers will also visit within the coming two weeks and file reports in the next Eurogram.

Gerald T. O'Connor, Colonel, USAF  
Commander, EOARD

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## Feature Article

### **Russians Demonstrate Breakthrough in Stationary Plasma Thrusters**

**Site Visit: Fakel Design Bureau, Kaliningrad, Russia, 14 – 18 Feb 2000.** Formed in the late 1950's to investigate electric propulsion for interplanetary travel, Fakel Design Bureau currently has 1000 employees working on electric propulsion missions for Russian, French, German, and US applications. They have developed nine series of thrusters from 20 W up to 30 kW.

During the visit, the first tests of a 100-W Stationary Plasma Thruster (SPT) developed under an EOARD contract were observed. AFRL/PR supported this work as part of their interest in small plasma thrusters for USAF small satellite missions, e.g. TECHSAT-21. The difficulty in earlier low-power SPT systems (< 200 W), was the low efficiency (~7%) attributed to the smaller path of ionization.

An SPT works by developing an axial electric field between discharge electrodes. Due to the lower power, Fakel decreased the thruster size to 50-mm diameter x 40 mm in length (size of a 35-mm roll of film). They also varied the xenon flow density and magnetic field intensity to try to increase the performance. Fakel also developed a cathode (no heat required compared to other cathode designs) that is roughly the size of a standard ink pen. The thruster total mass is 350 g.

Thruster tests covering a total of 9.5 hours at various settings were observed, including the following significant results (all stated efficiencies include the cathode):

#### **High Efficiency**

Input power: 94.5 W  
Thrust: 4.7 mN  
Specific Impulse: 1000 sec  
Efficiency: 24 %

#### **High Thrust**

Input Power: 120 W  
Thrust: 5.84 mN  
Specific Impulse: 863 sec  
Efficiency: 19.3 %

#### **Low Power**

Input Power: 53.4 W  
Thrust: 2.91 mN  
Specific Impulse: 502 sec  
Efficiency: 12.3 %

The visit included a tour of Fakel's five vacuum test chambers during a life test of the SPT- 140 (~5 kW). These results show that small SPT's look very promising for small satellite missions and represent a breakthrough in small thruster electric propulsion - 100% improvement in thruster efficiency. The thruster will be delivered to Edwards AFB for testing in the spring. EOARD is investigating several opportunities to collaborate with Fakel in the future.

## PROGRAM MANAGER REPORTS

*Dr. Charbel Raffoul  
Aeronautics*

**Conference: 18th International Congress on Instrumentation in Aerospace Simulation Facilities (ICIASF-99), Hosted by ONERA-Centre de Toulouse France, 14-17 June**

**1999.** The conference continued a series of congresses devoted to advancing the state of the art in instrumentation and measurement techniques. This congress was organized in cooperation with SUPAERO, the famous aerospace engineering school, located in the same scientific complex of ONERA. Rapid developments in aerospace sciences continue to challenge the international experimental scientific community to develop new ideas for better, easy to use and more efficient experimental techniques. Due to the complexity of the aerospace problems, the experimental approach is essential and must be performed in parallel with theoretical and numerical methods. From this point of view, the 18<sup>th</sup> ICIASF congress illustrates the development of more efficient mapping techniques used for surface or flow field measurements. Today's flight and wind tunnel tests particularly related to unsteady flows constitute a challenging domain for future instrumentation research.

More than ninety researchers from sixteen countries gathered to present their findings including new and improved mechanical, electrical, and optical measurement devices. The presentations were classified into Particle Image Velocimetry, Aero-Engines, Doppler Velocimetry, Sensitive Paint Techniques, Flight Instrumentation, Wind Tunnel Measurement Techniques, Test Techniques and High Speed Diagnostics sessions.

Of particular interest was the presentation "Phosphor Thermometry for High Temperature Gas Turbine Applications" from Imperial College (London, UK). Developments and preliminary experiments concerning the application of thermographic phosphor for surface temperature and heat flux measurements in gas turbine combustion chambers were presented. YAG:Dy has been shown to be best suited to measurements in combustion chambers. It is sensitive to temperatures in the range of 300 to 1500 K and emits light in the blue-green region of the spectrum where blackbody radiation is relatively weak and exhibits both modes of sensitivity. The

Electrostatic Assisted Combustion Chemical Vapor Deposition (EACVD), a new effective coating technique developed at Imperial College has proven to be more robust than chemical binders, coating techniques similar to those in thermal paints. In summary, the EACVD offers great potential for the application of thermographic phosphor to surfaces exposed to high temperatures.

Another interesting presentation was "Flow Velocities Visualization using Doppler Picture Interference Velocimetry" from the French-German Research Institute of Saint-Louis (ISL) (Saint-Louis, France). The paper discussed an improved technique for visualizing a velocity field in an entire plane by taking "Doppler Velocimetry Pictures" using Michelson interferometry. The method, which uses the shifts of interference fringes for flow velocity visualization, gives the possibility of becoming in the dark fringe region independent of varying light intensities resulting from the inhomogeneous distribution tracer particles. Therefore, only a discontinuous interpretation of the Doppler pictures is possible. The concept, using the grey values, is a very powerful tool that provides information at any point of the plane crossing the flow. This technique could be used for various flow phenomena, e.g. free jets, shocks and waves behind bodies.

The proceedings are available from DTIC. Mr. Gary Dale, AFRL, Wright Patterson Air Force Base, was elected the new chairman of the ICIASF. The next meeting will be held in 2001 in Cleveland, OH, USA. Mark Wernet from the NASA Glenn Research Center will be the local host.

**Conference: The 22nd International Symposium on Shock Waves (ISSW-22), hosted by Imperial College, London, UK, 18-23 July 1999.** The symposium was organized jointly by Imperial College (Prof. Richard Hillier) and the University of Southampton (Profs. G. Roberts and G. Ball). The program consisted of

280 papers, and more than 325 delegates from 19 countries attended. The ISSW series serves as the principal international forum for the reporting of recent advances in the field of shock wave research, and encompasses fundamental and applied work within engineering and the physical, chemical and biological sciences. ISSW22 covered a broad range of shock-related topics, including:

- Supersonic & Hypersonic Aerodynamics;
- Experimental Facilities and Diagnostics;
- Shock Reflection, Refraction & Focusing;
- Chemical Kinetics & Chemical Mechanisms;
- Shock/Boundary Layer Interactions;
- Medical Applications of Shock Waves;
- Detonation Phenomena, Supersonic Combustion & Scramjets;
- Blast Waves & Explosions;
- Shocks in Solids and Multi-Phase Flows;
- Numerical Methods; and
- Environmental and Safety Aspects.

Of particular interest was “Hypersonic Airbreathing Propulsion” by Dr. A. Paull (U. of Queensland, Australia) in the first plenary session. Dr. Paull indicated that although supersonic combustion ramjets or scramjets are currently the most promising method for achieving hypersonic airbreathing propulsion, an operational example of a scramjet has yet to be developed. He highlighted the challenges outlined by Erdos (1997). A call was made for “the development of an understanding of basic aerophysics of an engine, benchmark quality data, proof of concept testing and the compilation of a database that will support the design of an engine”.

In the plenary lecture, “Shock wave/boundary layer interaction and associated control techniques,” Professor Jean Delery, ONERA, Meudon, France, described the physical features of a shock wave reflection with boundary layer separation and various shock interaction control techniques such as ‘energizing’ the boundary layer before it meets the shock wave or acts directly in the interaction region. Active and hybrid control

arrangements were also considered for wave and friction drag reduction. The presentation gave a physical description of the phenomena involved in these different control techniques by considering detailed experimental flow analyses performed in typical interactions under control conditions.

The proceedings are available on CD-ROM, and may be obtained from DTIC.

**Conference: International Symposium on Quantitative Feedback Theory (QFT) and Robust Frequency Domain Methods, Hosted by University of Natal, Durban, South Africa, 26-27 August 1999.** The symposium attracted 27 delegates from nine countries. AFIT Professors emeritus Constantine Houpis and Isaac Horowitz presented plenary talks covering more than a century of collective experience in feedback control. Sessions covered process control, norm based design methods, QFT theory and computation, cascade control, multivariable and non-linear control. A feature of the conference was the combination of norm-based methods and QFT design. Debate at the level of design philosophy was very constructive. Although the number of local participants, especially those from industry, was disappointing, the conference was rated as a success. The proceedings are available in book form (ISBN 1-86840-330-0, editors E. Boje, and E. Eitelberg).

**Conference: 7<sup>th</sup> International Workshop on the Physics of Compressible Turbulent Mixing, Hosted by the State Regional Educational Center of the Ministry for Atomic Energy, St. Petersburg, Russia, 5-6 July 1999.** The Russian Federal Nuclear Center, the Russian Scientific Research Institute of Experimental Physics (VNIIEF), the ‘Ioffe’ Physical Technical Institute and the ‘Sarov’ Physical Technical Institute organized the workshop with broad U.S. and European financial support.

The workshop's main thrust concerned investigations of instabilities and turbulence modeling associated with explosives or fusion reactors. One area concerned the instabilities that result at the accelerating interface between media of differing densities. This so-called Richtmyer-Meshkov instability results when a density gradient aligns with an acceleration vector. This instability limits the compression ratios achieved in inertial confined plasmas and represents one of the limiting factors in the controlled generation of fusion power when using inertial confinement. Additional areas discussed included modeling of Rayleigh-Taylor instabilities and blast wave instabilities.

Of particular interest was the paper "Trans-Ion-Acoustic Plasma Dynamics: New Possibilities in Aerodynamics," by V. Pavlov, Yu. Serov, and I. Smirnovski, Ioffe Institute personnel. The theme of this paper is that plasma instability result in a strong interaction between charged and neutral particles in the plasma aerodynamic experiments. This so-called ion-acoustic soliton is generated and observed in several experiments. A photograph of a sphere flying through externally generated plasma was shown. A second "bow" shock wave appears in the photograph. Dr. Serov explained that this picture captures an unsteady phenomenon and provides direct evidence of the ion-acoustic soliton. Ioffe Institute personnel also presented "Measurement of the Velocity of Sound in Discharge Air Plasma," by A. Baryshnikov, I. Basargin, and M. Christyakova.

Attendance at the workshop provided insight into a technical community that investigates many of the same basic technologies as the aerospace community (i.e. instabilities, transition, turbulence, mixing, etc.). The opportunity for collaboration and cross-fertilization of ideas between the two communities should be pursued since little communication presently occurs.

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*Major Jerry J. Sellers*  
*Astronautics*

**Meeting, US Space Opportunities Briefing, UK Department of Trade & Industry (DTI), 11 February 2000.** International Technology Promoters, a support contractor to the DTI, hosted the meeting. Approximately 50 representatives from UK high-tech industries attended the meeting. The purpose was to inform UK industry about business opportunities within US space-related markets. Specifically, speakers summarized recent UK trade delegations to Wichita, Kansas, Clear Lake (Houston), Texas and Denver/Boulder/Colorado Springs, Colorado. Representatives from the Clear Lake Economic Development Foundation (CLAEDF) also presented their goals of strengthening the local economy through expanded ties with UK industry. Overall, the forum highlighted the keen interest by UK industry in gaining access to the US space market. US Government research agencies can capitalize on this interest and learn more about untapped UK technologies by hosting future UK government-sponsored trade delegations. An upcoming delegation from the world-class UK Formula One racing industry is slated to visit the US in mid-2000 to highlight their state-of-the-art expertise in system health monitoring, telemetry, automotive technologies, materials and system engineering. Efforts are underway through EOARD for these experts to visit some NASA centers.

**Press Release: The UK Government announced in December a plan to invest £15M (\$25.5M) in small satellite technologies over the next three years.** The funding is intended to help transfer the UK's world-leading capability in small satellites from the academic into the scientific and commercial markets. The objective is to stimulate industry to invest in small satellite missions, particularly for satellite communications - potentially the largest and most rapidly expanding market for space products. The UK's expertise is particularly strong

in micro-satellites (less than 100kg) and in the enabling sensor and component technologies. To build on this strength, and to secure the corresponding user benefits, the UK is seeking to provide support to UK companies for the development of key small satellite technologies and payloads through the European Space Agency (ESA) and national activities. The UK is also developing a new Small Satellite Program to co-fund additional initiatives such as a limited number of small satellite missions focused on clear customer requirements. Successful proposals will be part-funded (up to 50%) by this Small Satellite Program. The rest of the funds will normally be provided by the industrial partner(s) in the project, but may also include user Government departments and agencies of other governments where their involvement can be shown to substantially aid subsequent projects. Announcements are expected in April 2000. For more information, see the British National Space Centre (BNSC) homepage (<http://www.bnsc.gov.uk/smallsat/indexa.htm>)

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*Mr. Jay Howland*  
*Physics and Energetic Materials*

**Site Visit: Institute of Physics, Charles University, Prague, Czech Republic, 31 Jan 2000.** Professor Pavel Hoschl of the Institute of Physics organized the meeting where the principal topic was progress on infrared (IR) detector improvements. The wide bandgap binary semiconductor CdTe (CT) with the bandgap 1.5eV at room temperature has been used as a source material for preparation of detectors of gamma radiation in the energy range 10-100 keV. Ct has also been used as a substrate for fabrication of detectors of infrared radiation on the basis of CdHgTe and also as a material for electro-optical modulation of signals. It is necessary to improve both structural and material parameters of the single crystalline CT in order to optimize the function of the above elements. According to the state-of-the-art of technology of

growth of CT single crystals both demands lead to minimization of influence of native point defects, which can affect mobility and lifetime of carriers or the concentration of precipitates of one of the components (Cd, Te) at higher defect concentrations. The Institute of Physics researchers are varying the temperatures and pressures of the components and looking at the resulting equilibrium concentrations of defects in the whole region of stability of the solid phase in order to improve the semiconductor properties.

**Site Visit: Czech Air Force Passive Surveillance Systems (PSS) Center, Prague, Czech Republic, February 2000.** A second stop was arranged by Col. Peter Svoboda to view the Czech Air Force Passive Surveillance Systems (PSS) Center, Prague. The concept of PSS was invented by the Czech Army and further developed by the Tesla and ERA companies. It is a non-emitting method of accurately determining the position, type and operation mode of pulse emitters, with very high location and tracking accuracy (10 – 100 meters RMS). Using three passive receiver sites, it can automatically track 200-300 targets within a 120 degree arc at ranges up to 450 km and has high anti-radar jamming resistance.

Dr. Vladimir Kubecek, ERA Technical Director, briefed the progress to date of computer modeling the PSS systems under an EOARD contract. There are currently three different PSS systems in use or development, all based on the well proven passive Time Difference Of Arrival (TDOA) multilateration technique using signals of air, ground, and naval radar, jammer, SIF/IFF transponder, TACAN/DME interrogator, Datalink and other pulse emitters. The mobile PSS VERA-E is an ELINT and Passive Surveillance System designed for location, identification and tracking of air, ground, and naval ship targets. The VERA-ASCS is a high performance sensor designed to be an efficient source of position and identification data of aircraft on the airport surface and approaches. The VERA-AP is a precision

location system to accurately track aircraft in flight to within a few meters and improves flight safety while decreasing the normal 1000-foot altitude separation.

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*Major Tim Lawrence  
Space Technology*

**Site Visit: Polyflex Aerospace Ltd, Cheltenham, UK, 6 January 2000.** Polyflex Aerospace Ltd UK hosted an information meeting on their latest developments in small satellite propulsion system expulsion systems. Polyflex is a 30-person mechanical engineering firm specializing in the design, development, and manufacture of high-pressure components and systems for space application. They just finished constructing a 120 square-meter clean room, which along with their existing vibration test unit and thermal vacuum chamber will allow complete space qualification of their propulsion systems. Polyflex has existing space projects in nitrous oxide expulsion, cold gas propulsion, and liquid storage propulsion systems for small satellites at Surrey Satellite Technology (UK); a helium tank for Oxford University's space sensor program (UK); and a check valve for DASA (Germany). They are currently spending in-house money for low-cost latch valves for chemical propulsion systems, shape memory metal valves, thermal-viscous flow control valves and xenon feed systems for electric propulsion. Several of these systems offer unique and low cost options to off-the-shelf expulsion systems for electric propulsion.

**Site Visit: Surrey Space Centre, Guildford UK, 13 Jan 2000.** The Surrey Space Centre hosted a review of their latest small satellite project - SNAPSAT. SNAPSAT is a 7-kg nanosatellite scheduled for launch in Russia this summer. SNAPSAT will be mounted to the top of a 50-kg "mother" microsatellite and then be deployed in space. It has the following design features:

- two reaction wheels and magnetorquers for attitude control,
- uplink/downlink to the Surrey ground station,
- 12 W of solar-array power,
- a butane propulsion system for orbit maneuvering, and
- a camera for remote sensing of the microsatellite.

The mission objective is to deploy the nanosatellite at 1 m/s and have it return to image the microsatellite. Surrey's design for the propulsion system is quite unique. To maximize volume available in the spacecraft, the system took a standard 1/4" pipe and bent it in five turns so it wound itself into the spacecraft. The pipe represents a pressure vessel and will store butane gas in its liquid state. The valve, solenoid, and thruster will be mounted to the bottom of the spacecraft. A standard tank, piping, valve, transducer, and thruster system would not have 'fit' into the nanosatellite structure. The propulsion system will provide a mission delta v of 5 m/s.

**Conference: HQ AFOSR, Arlington, VA, 27 Jan 2000.** Dr. Mitat Birkan sponsored a seminar on "Space Protection - Plume Contamination, and Characterization," with attendees from AFRL/PR, BMDO, AFOSR, EOARD, AEDC, and Russia. Dr Mikhail Ivanov of ITAM in Siberia gave the keynote address. He presented his results on numerical modeling of high altitude thruster plumes. He has specialized in rarefied gas dynamics studies in the transition region between free molecular and continuum flow. Applications of his code have been applied to micronozzle flow and Mir re-entry control modeling. EOARD presented ongoing and possible future sponsored research activities in electric propulsion. The group was very interested in the possibility of a study on Russian Hall thruster flight data.

**Conference: STAIF-00, Albuquerque, NM, 1 – 4 Feb 2000.** EOARD sponsored the attendance of five European scientists to the Space Technology and International Forum, in

support of the Breakthrough Propulsion Physics Program sponsored by NASA. A brief summary of their work and presentations follows:

- Dr. David Fearn, Imperial College, UK, "Research in High Specific Impulse Gridded Ion Propulsion Systems." His theory shows that a gridded ion thruster can achieve a specific impulse of 150,000 sec (compared to 4,000 sec today). This performance would require at least 10kV into the grid compared to 1 V today. Work by the Japanese in fusion energy show that this is experimentally possible for short duration.
- Dr. Martin Tajmar, Vienna University, Austria, "On the Manipulation of Gravity using Electromagnetic Energy." Dr. Tajmar showed the impact of a divergent current and its mass flow into an object. His experimental apparatus consisted of a box suspended by four wires inside a Faraday cage. His observations showed that the impulse derived from current is much less than other electric propulsion systems and this approach really has no application for space transportation.
- Chris van den Broeck, Starlabs, Belgium, "Discussion on Alcubierre's Warp Drive." The concept postulates that warp bubbles exist and can be used for intergalactic travel. The problem is that the bubble concept is that it violates the energy conditions and classical relativity. They also require more energy in the Universe to create them. His future work will investigate if subluminal positive energy bubbles are possible.
- Dr. Sergey Krasnikov, St Petersburg Astrophysics Institute, Russia, "Towards a Traversable Wormhole." Dr. Krasnikov's research showed that wormholes are stable

and macroscopic. Their creation would require enormous energy, but the mouths would be very close, so distant intergalactic travel does not look feasible. For future work, he intends to show that traversible wormholes exist under more realistic conditions and still do not violate current energy laws.

- Dr Andrey Gulevich, the Institute of Nuclear Power, Obinsk Russia, "Nuclear Pumped Lasers for Space Propulsion." His institute developed the Topaz space nuclear reactors and pioneered the use of reactors to drive lasers for propulsion. His calculations show that a 100 N thrust system at 2000-sec specific impulse is feasible.

All presentations generated interest in future collaboration from the US participants.

**Site Visit: DERA Space Department, Farnborough, UK, 7 Feb 2000.** EOARD accompanied Dr. Janni, Colonel Reznick and Dr. King of AFOSR to a meeting discussing DERA's recent space research activities. Dr. Graham Davidson, Chief of the Space Department, gave an overview presentation of their research activities involving a staff of 185 employees and an annual turnover of \$52 million. Highlights of their space activities include the Space Test Research Vehicle Program (STRV), ion propulsion, and space environment research. Mr. Richard Blott discussed the planned launch of two 100-kg spacecraft this summer with AFRL/VS, BMDO, SMC/TEL, and NASA experiments. After a tour of the space test facilities and the spacecraft undergoing environmental testing, discussions of possible expanded collaboration between the USAF and DERA were held.



## CONFERENCE SUPPORT

EOARD promotes technical interchange by supporting and co-sponsoring technical workshops and mini-symposia at overseas conferences. We often receive in return proceedings and attendance for one or more Air Force representatives. Air Force R&D personnel attending or considering attending European conferences should contact EOARD for further information. For further details on the conferences below contact the program manager indicated (see footnotes). **Bi-service and tri-service support efforts are in bold print.**

<i>Dates (2000)</i>	<i>Location</i>	<i>Conference/Workshop Title</i>	<i>LO<sup>1</sup></i>
28 Feb - 3 Mar 00	Zurich, SW	3rd Intl. Conference on Flow Interaction (SCART 2000)	CNR
7 - 8 Mar 00	Orsay, France	Nonlinear Partial Differential Equations: Applications to Fluid Mechanics and Meteorology None yet	CNR
12 - 16 Mar 00	Davos, Switzerland	Int'l Conference in Organic Nonlinear Optics 5 (ICONO'5) <a href="http://www.icono5.ethz.ch">http://www.icono5.ethz.ch</a>	CMS
13 - 15 Mar 00	Lampoldshausen	4. International Symposium on Liquid Space Propulsion, Scientific Progress in the Service of Space Access at the Beginning of the Third Millenium <a href="http://www.la.dlr.de/en/ra/events">www.la.dlr.de/en/ra/events</a>	TL
2 - 7 Apr 00	University of Gottingen	GAMM 2000 <a href="http://GAMM2000.dlr.de/">http://GAMM2000.dlr.de/</a>	CNR
3 - 7 Apr 00	Eilat, Israel	Multiscale Computational Methods in Chemistry	RSF
<b>4 - 5 Apr 00</b>	<b>Cranfield University, Bedford UK</b>	<b>Workshop on Helicopter Damage Tolerance</b>	<b>RSF</b>
5 - 7 Apr 00	IVTAN-Moscow- Russia	The Second Workshop on Magneto- and Plasma Aerodynamics for AeroSpace Applications Not Yet	CNR
9 Apr 00	Davos, Congress Centre, Switzerland	AP2000 Millennium Conference on Antennas and Propagation <a href="http://www.estec.esa.nl/CONFANNOUN/AP2000/">http://www.estec.esa.nl/CONFANNOUN/AP2000/</a>	GTO
10 - 14 Apr 00	Saint-Louis, France	First European Forum on Ballistics of Projectiles 'EFBP' <a href="http://www.efbp2000.com">www.efbp2000.com</a>	CNR
16 - 18 Apr 00	Tel Aviv, Israel	Leonid MAC Workshop 2000 <a href="http://leonid.arc.nasa.gov/workshops/">leonid.arc.nasa.gov/workshops/</a>	JJS
<b>17 - 19 Apr 00</b>	<b>Berlin, Germany</b>	<b>Third International Micro Materials Conference and Exhibition <a href="http://www.micromaterials.com">www.micromaterials.com</a></b>	<b>RSF</b>
30 May - 3 Jun 00	St. Petersburg, Russia	Thermochemical processes in plasma aerodynamics Not yet	CNR
30 May 00	Vienna, Austria	Comparative & Veterinary Electrophysiology of Vision tbd	RSF
30 May - 2 Jun 00	Edinburgh Int'l Conference Centre, Scotland	EUROEM 2000	CMS
31 May - 2 Jun 00	Stuttgart, Germany	Workshop on Thermal and Environmental Barrier Coatings	RSF
<b>19 - 24 Jun 00</b>	<b>Limassol, Cyprus</b>	<b>Multiscale Materials Phenomena in Harsh Environments</b>	<b>RSF</b>
19 - 29 Jun 00	Hersonissos, Greece	Advanced Study Institute on Space Storms and Space Weather Hazards <a href="http://sat2.space.noa.gr/~daglis/asi2000.html">http://sat2.space.noa.gr/~daglis/asi2000.html</a>	JJS
<b>26 - 28 Jun 00</b>	<b>Cambridge University, Cambridge UK</b>	<b>Materials Engineering - a Forward Look (The Ashby Symposium)</b>	<b>RSF</b>
27 - 29 Jun 00	Royal Aeronautical Society, London, UK	Fourth Test & Evaluation International Aerospace Forum none yet	CNR
27 - 30 Jun 00	Barcelona, Spain	Eighth European Turbulence Conference (ETC8) <a href="http://etc8.litec.csic.es/">http://etc8.litec.csic.es/</a>	CNR
9 - 15 Jul 00	Novosibirsk	International Conferences on Methods of Aerophysical Research (ICMAR'2000) <a href="http://www.itam.nsc.ru/icmar2000/">http://www.itam.nsc.ru/icmar2000/</a>	CNR
<b>10 - 12 Jul 00</b>	<b>Oxford, UK</b>	<b>Sixth International Conference on Residual Stress</b>	<b>RSF</b>
<b>10 - 13 Jul 00</b>	<b>Lisbon, Portugal</b>	<b>Tenth International Symposium on Applications of Laser Techniques to Fluid Mechanics <a href="http://in3.dem.ist.utl.pt/lisboa-laser/">http://in3.dem.ist.utl.pt/lisboa-laser/</a></b>	<b>CNR</b>
16 - 21 Jul 00	Ecole Nationale Supérieure, Bordeaux, France	9th Int'l Workshop on Laser Physics - LPHYS 2000'	CMS
27 - 31 Aug 00	Groningen, The Netherlands	European Conference on Visual Perception <a href="http://www.ecvp.org">http://www.ecvp.org</a>	GTO
<b>28 Aug - 1 Sep 00</b>	<b>Brijuni island - Croatia</b>	<b>Brijuni conference - Important problems for the XXI century <a href="http://www.brijuni-conference.irb.hr">http://www.brijuni-conference.irb.hr</a></b>	<b>JJS</b>
11 - 14 Sep 00	World Trade Center, Barcelona, Spain	European Congress on Computational Methods in Applied Sciences and Engineering (ECCOMAS 2000) <a href="http://www.cimne.upc.es/eccomas">http://www.cimne.upc.es/eccomas</a>	CNR
18 - 22 Sep 00	Florence, Italy	XIII Int'l Symposium on Gas Flow & Chemical Lasers and High Power Laser Conference	CMS
27 - 29 Sep 00	Amsterdam	How eye movements serve the needs of vision in the natural world	GTO
2 - 6 Oct 00	Crimea, Ukraine	Singular Optics: Fundamentals & Applications	CMS

<sup>1</sup> CMS-Martin Stickley; CNR-Charbel N. Raffoul; GTO-Gerald T. O'Connor; JAH-Jay A. Howland; JJS-Jerry J. Sellers; RSF- Robert S. Fredell; TL-Tim Lawrence

## WINDOW ON SCIENCE

EOARD initiates and promotes technical liaison between Air Force and foreign scientists very effectively with the Window On Science (WOS) program, through which we can arrange and fund visits of foreign scientists to selected Air Force facilities. To nominate a WOS candidate, contact your Technical Director or your EOARD discipline representative. WOS visitors currently on contract are listed below. For further details contact the program manager indicated (see footnotes). **Bi-service and tri-service coordinated visits are in bold print.**

<i>Dates (1999)</i>	<i>Traveler</i>	<i>Country</i>	<i>Topic</i>	<i>Location(s) of US Visit<sup>f</sup></i>	<i>LO<sup>2</sup></i>
<b>8 - 22 Jan 00</b>	<b>Dr. Valentin Bityurin</b>	<b>Russia</b>	<b>Plasma Aerodynamics</b>	<b>Reno; NASA Ames; Tullahoma; AFRL/WPAFB</b>	<b>CNR</b>
8 - 14 Jan 00	Dr. Georgy Karabadzhak	Russia	Space Based Double Channel Imaging Sensor	attend AIAA 38th Aerospace Conference 10-13 Jan 00	JAH
8 - 14 Jan 00	Dr. Yury Plastinin	Russia	Space Based Double Channel Imaging Sensor	attend AIAA 38th Aerospace Conference 10-13 Jan 00	JAH
<b>8 - 14 Jan 00</b>	<b>Dr. Ismet Gursul</b>	<b>United Kingdom</b>	<b>Fin Buffetting</b>	<b>AIAA-Reno Hilton</b>	<b>CNR</b>
<b>9 - 22 Jan 00</b>	<b>Dr Vincent G Couaillier</b>	<b>France</b>	<b>Computational Fluid Dynamics; Aeroacoustics</b>	<b>AIAA-Reno; AFRL/Dayton, NASA Glenn; Allison/Indianapolis</b>	<b>CNR</b>
9 - 19 Jan 00	Professor Alexander B. Lessin	Israel	Dual Mode Sensor Capabilities	Attend the AIAA 38th Aerospace Conference 10-14 Jan 00 at Reno, Nv then meeting with BMDO 17-18 Jan 00 Washington DC	JAH
9 - 22 Jan 00	Professor Anatoly Kharitonov	Russia	Hypersonic Wind Tunnel	AIAA Aerospace Meeting Reno NV, Boeing Long Beach, NASA LaRC	PJO
9 - 16 Jan 00	Dr. Nikolay Zheludev	United Kingdom	Nonlinear optics of confined, liquid gallium	Tucson, AZ and USAFA, Colorado Springs, CO	CMS
19 - 23 Jan 00	Dr. R Peter Lindstedt	United Kingdom	Combustion & Detonation	NASA GRC, AFRL/WPAFB	CNR
20 - 29 Jan 00	Professor Michael Lewis	United Kingdom	Ceramic materials research	AFRL/MLLN, Wright-Patterson AFB OH, Conf. On Engineering Ceramics, Cocoa Beach FL	RSF
21 Jan - 2 Feb 00	Dr. Vitali Grouzdev	Russia	Ultrafast laser interaction with solids.	AFRL/DEOB, Kirtland AFB, NM	CMS
21 Jan - 12 Feb 00	Mr. Tilmann Heil	Germany	Nonlinear dynamical behavior of diode lasers	AFRL/DELO, Kirtland AFB, NM.	CMS
21 Jan - 1 Feb 00	Professor Jacques Lamon	France	Thermomechanical behavior ceramic composite mat'ls	Conference on Engineering Ceramics, Cocoa Beach FL; AFRL/MLLN, Wright-Patterson AFB OH	RSF
29 Jan - 4 Feb 00	Dr Chris Van Den Broeck	Belgium		STAIF, Albuquerque, NM	PJO
29 Jan - 2 Feb 00	Dr Craig Underwood	United Kingdom	Microsatellites	USAF Academy, CO	JJS
29 Jan - 5 Feb 00	Dr David Fearn	United Kingdom	Advanced Ion Engine Presentation to STAIF-QO Conference	STAIF, Albuquerque, NM	TL
29 Jan - 4 Feb 00	Dr Martin Tajmar	Austria	Breakthrough Propulsion Physics	STAIF, Albuquerque	PJO
29 Jan - 5 Feb 00	Dr Sergui Krasnikov	Russia	Brief Staif-00 Conference on Breakthrough Propulsion Concept	Albuquerque, NM	TL
29 Jan - 5 Feb 00	Dr Andrei Goulevitch	Russia	Breakthrough Propulsion Research	Albuquerque, NM	TL
5 - 13 Feb 00	Dr. Frantisek Farnik	Czech Republic	Space Environment research using the HSRX instrument	Vandenberg, AFB, CA	JJS
2 - 7 Apr 00	Professor Ian Postlethwaithe	United Kingdom	Control Design	NASA GRC	PJO
2 - 7 Apr 00	Dr Declan Bates		Control Design	NASA GRC	PJO
3 - 8 Apr 00	Mrs. Nataliya Antonova	Ukraine	Structure and properties of the Ti-Al-Ga alloys and the phase diagram of the Ti-Ga system	13th Int. Conf. on Solid Compounds of Transition Elements - SCTE2000 Stresa Italy	RSF
24 - 28 Apr 00	Dr. Mireille Florence Levy	United Kingdom	EM Low grazing		RSF
25 Apr - 5 May 00	Professor Richard Geoffrey Carter	United Kingdom	Vacuum Electronics	University of Wisconsin, Monterey Tube Conference	RSF
27 Apr - 2 May 00	Professor Iwan Prys Williams	United Kingdom	Meteors and interplanetary dust	AFRL/VSBS, Hanscom AFB, MA	CMS
13 - 20 May 00	Dr. Luigi Foschini	Italy	Meteoroid hazard to satellites	AFRL/VS, Hanscom AFB, MA	CMS
19 - 29 Jun 00	Professor John Plane	United Kingdom	The impact of extra-terrestrial dust on the upper atmosphere	AFRL/VS, HRS	CMS

Dates (1999)	Traveler	Country	Topic	Location(s) of US Visit <sup>1</sup>	LO <sup>2</sup>
30 Jul - 10 Aug 00	Dr. Adrian Stern	Israel	Restoring images degraded by motion	AFRL/DEBS, Kirtland AFB, NM., and San Diego, CA.	CMS
19 - 24 Aug 00	Professor Ivor Smith	United Kingdom	Boundary Layer Transition & Turbomachinery Flows	Minnowbrook, NY	CNR
19 - 24 Aug 00	Professor Torsten H Fransson	Sweden	Boundary Layer Transition & Turbomachinery Flows	Minnowbrook, NY	CNR
19 - 24 Aug 00	Dr. Howard Hodson	United Kingdom	Boundary Layer Transition & Turbomachinery Flows	Minnowbrook, NY	CNR
19 - 24 Aug 00	Dr. Anthony Mark Savill	United Kingdom	Boundary Layer Transition & Turbomachinery Flows	Minnowbrook, NY	CNR
19 - 24 Aug 00	Professor Jonathan Gostelow	United Kingdom	Boundary Layer Transition & Turbomachinery Flows	Minnowbrook, NY	CNR
19 - 24 Aug 00	Professor Neil Sandham	United Kingdom	Boundary Layer Transition & Turbomachinery Flows	Minnowbrook, NY	CNR
19 - 24 Aug 00	Dr. Mark Wyatt Johnson	United Kingdom	Boundary Layer Transition & Turbomachinery Flows	Minnowbrook, NY	CNR
19 - 24 Aug 00	Prof. Erik Dick	Belgium	Boundary Layer Transition & Turbomachinery Flows	Minnowbrook, NY	CNR
19 - 24 Aug 00	Professor Nicholas Cumpsty	United Kingdom	Boundary Layer Transition & Turbomachinery Flows	Minnowbrook, NY	CNR
19 - 24 Aug 00	Prof. Ian Poll	United Kingdom	Boundary Layer Transition & Turbomachinery Flows	Minnowbrook, NY	CNR
19 - 24 Aug 00	Prof. Ulrich Rist	Germany	Boundary Layer Transition & Turbomachinery Flows	Minnowbrook, NY	CNR
19 - 24 Aug 00	Professor Michael Gaster	United Kingdom	Boundary Layer Transition & Turbomachinery Flows	Minnowbrook, NY	CNR
10 - 23 Sep 00	Professor Alexey Ustinov	Germany	Applied Superconductivity	HRS, MIT, NRL, Applied Superconductivity Conference, Virginia Beach	RSF

<sup>1</sup> AFRL Research Sites--**ARS**: Armstrong Research Site, Brooks AFB, TX; **ERS**, Edwards Research Site, Edwards AFB, CA **HRS**: Hanscom Research Site, Hanscom AFB, MA; **PRS**: Philips Research Site, Kirtland AFB, NM; **RRS**, Rome Research Site, Rome, NY; **WRS**: Wright Research Site, Wright-Patterson AFB, OH; Other sites: **AEDC**: Arnold Engineering Development Center, Arnold AFB, TN; **USAF**: Air Force Academy, Colorado Springs, CO; **ARL**: Army Research Laboratory

<sup>2</sup> CMS-Martin Stickley; CNR-Charbel N. Raffoul; GTO-Gerald T. O'Connor; JAH-Jay A. Howland; JJS-Jerry J. Sellers; PJO-Peter J. Ouzts; RSF-Robert S. Fredell; TL-Tim Lawrence

### EOARD Technical Personnel

US Address:

EOARD PSC 802 BOX 14

FPO AE 09499-0200

COMMERCIAL phone/fax: (+44) (207) 514-4950/4960

UK Address:

223/231 Old Marylebone Road

London NW1 5TH UK

DSN: 235-4950/4960

Name	Functional Area	Phone 514-xxxx	E-mail name first.last@london.af.mil
Colonel Gerald T. O'Connor	Commander	4376	Gerald.Oconnor
Lt Col Robert S. Fredell	Technical Director	4505	Rob.Fredell
Lt Col David Burns	Sensors	4955	David.Burns
Major Jerry J. Sellers	Astronautics	4318	Jerry.Sellers
Major Timothy J. Lawrence	Space Technology	4285	Tim.Lawrence
Dr. Chris Reuter	Information Technology and C4I	4474	Chris.Reuter
Dr. Charbel N. Raffoul	Aeronautical Sciences	4299	Charbel.Raffoul
Dr. Peter J. Ouzts	NASA European Liaison	4951	Peter.Ouzts
Dr. C. Martin Stickley	Lasers, Optics, and Materials	4354	Martin.Stickley
Dr. Roy Phillips	Policy and Strategy	4953	Roy.Phillips
Mr. Jay A. Howland	Physics & Ballistic Missile Defense	4437	Jay.Howland

**Joint Points of Contact**

EOARD shares its London office, the Edison House, with other agencies from the US Army, Navy, and Air Force. For information about the functions and activities of these agencies contact those listed below. Telephone prefixes are DSN 235- or commercial +44-207-514-xxxx.

<u>Agency</u>	<u>Points of Contact</u>	<u>Phone Extension</u>	<u>e-mail</u>
<b>US Army Research and Development Standardization Group (USARDSG)</b>	Col Joe Girlando (Commander)	4906	<a href="mailto:jgirlando@army.ehis.navy.mil">jgirlando@army.ehis.navy.mil</a>
	Lt Col Tom McWhorter (Standardization Division Chief)	4935	<a href="mailto:tmcwhorter@army.ehis.navy.mil">tmcwhorter@army.ehis.navy.mil</a>
<b>European Research Office (ERO), Army</b>	Dr. John Zavada, Director	4907	<a href="mailto:jzavada@army.ehis.navy.mil">jzavada@army.ehis.navy.mil</a>
<b>Office of Naval Research, International Field Office (ONRIFO), Europe</b>	CAPT Dennis Ryan, Commander	4417	<a href="mailto:drvan@onreur.navy.mil">drvan@onreur.navy.mil</a>
	Dr. Michael Pectorius, Technical Director	4508	<a href="mailto:mpestorius@onreur.navy.mil">mpestorius@onreur.navy.mil</a>
<b>Research and Development Liaison Office (RDLL), Air Force</b>	Col (sel) Mike Krimmer, Director	4956	<a href="mailto:mkrimmer@rdll.af.mil">mkrimmer@rdll.af.mil</a>
	Mr. Craig Grand Pre, Deputy	4668	<a href="mailto:cgrandpre@rdll.af.mil">cgrandpre@rdll.af.mil</a>

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